Front Controller Revision 3

MAC EV VI

LV/HV Electronics

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1 Key Contacts

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Manufacturing/Assembly Lead(s): Sapna Suthar, Diya Bahl

2 Purpose

<briefly describe the purpose of this design with respect to its parent system or the vehicle at large.>

The Front Controller is the primary ECU in the vehicle and is responsible for various startup, safety, and control sequences. This startup sequence includes enabling the Tractive System (TS) and entering ready-to-drive mode. Additionally, it involves reading critical vehicle parameters such as accelerator and brake pedal positions, steering angle, and suspension travel. Other functions encompass activating the ready-to-drive speaker, managing brake lights, and sending torque requests to motor controllers. The system also incorporates advanced features like torque vectoring and traction control algorithms. Communication is established via Controller Area Network (CAN) with several components including the low-voltage controller, dashboard screen, motor controllers, and Orion Battery Management System (BMS) across three separate CAN buses. Lastly, various shutdown circuit connections are in place for safety, including inertia switch, dash shutdown button, brake overtravel switch, front right motor interlock, and front right motor connector interlock. Additional safety circuits involve the BSPD safety circuit and the high voltage interlock (HVIL) feedback.

3 Design Visuals

3.1 Schematic Design

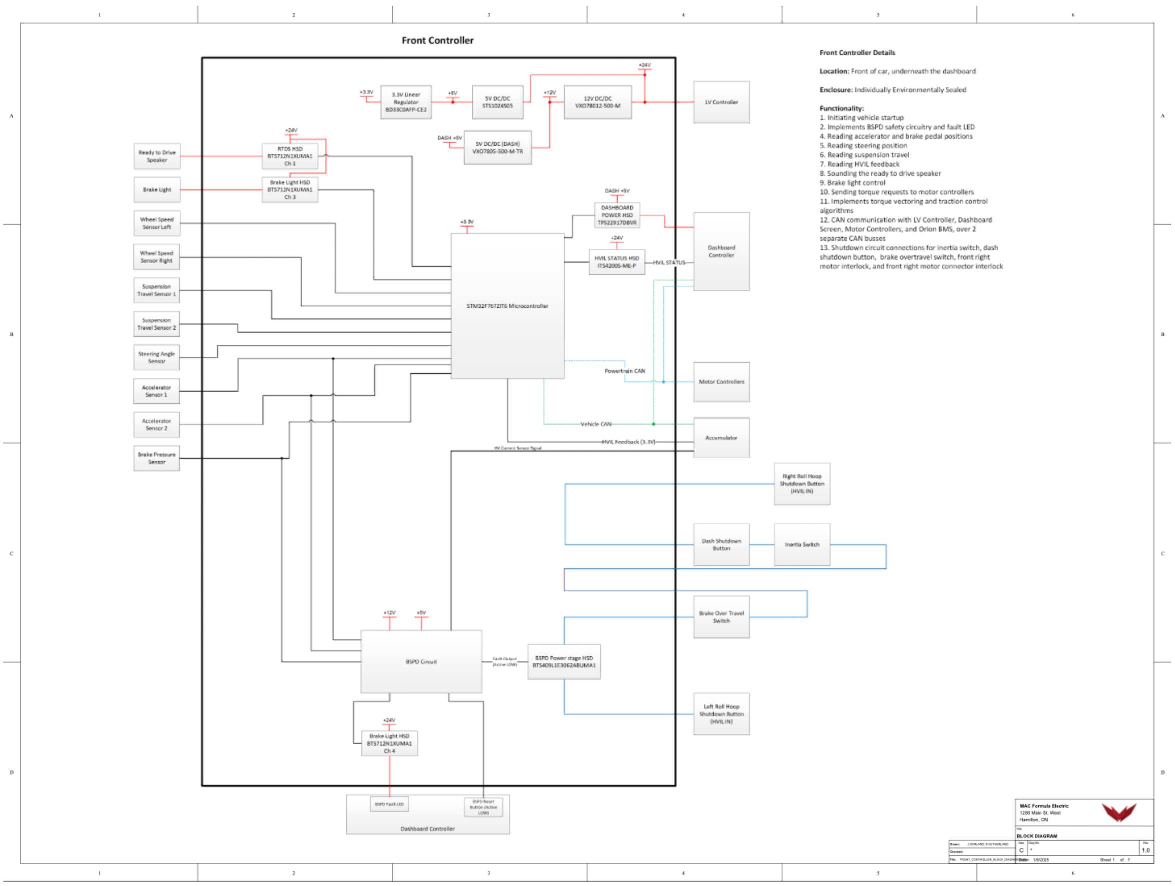


Figure 1: Block Diagram

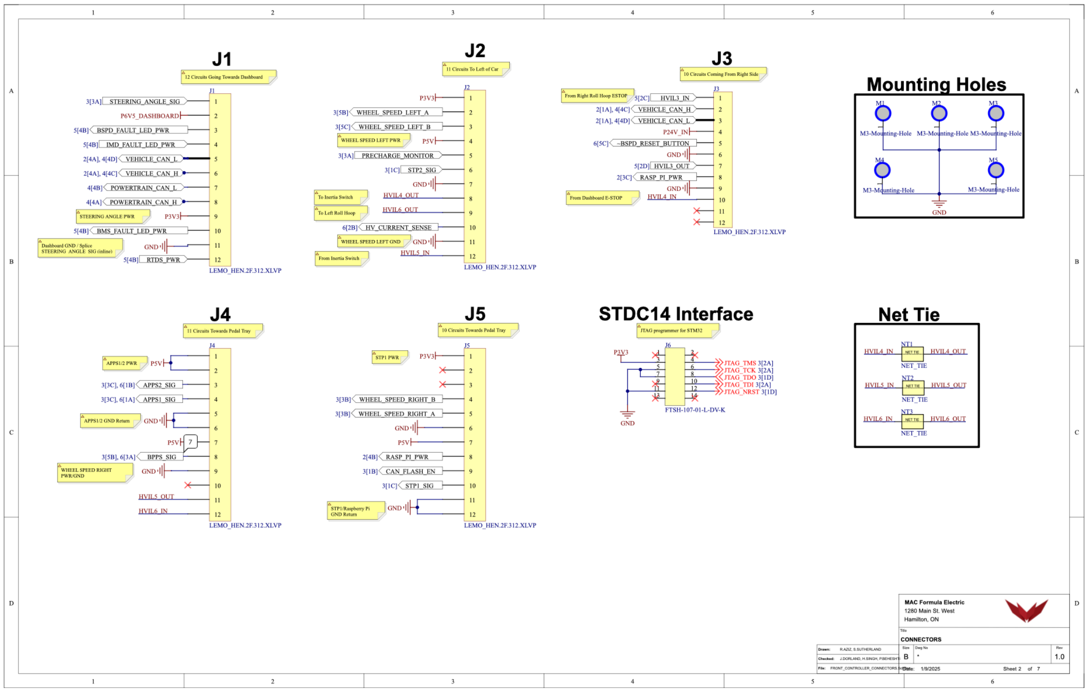


Figure 2: Connectors Schematic

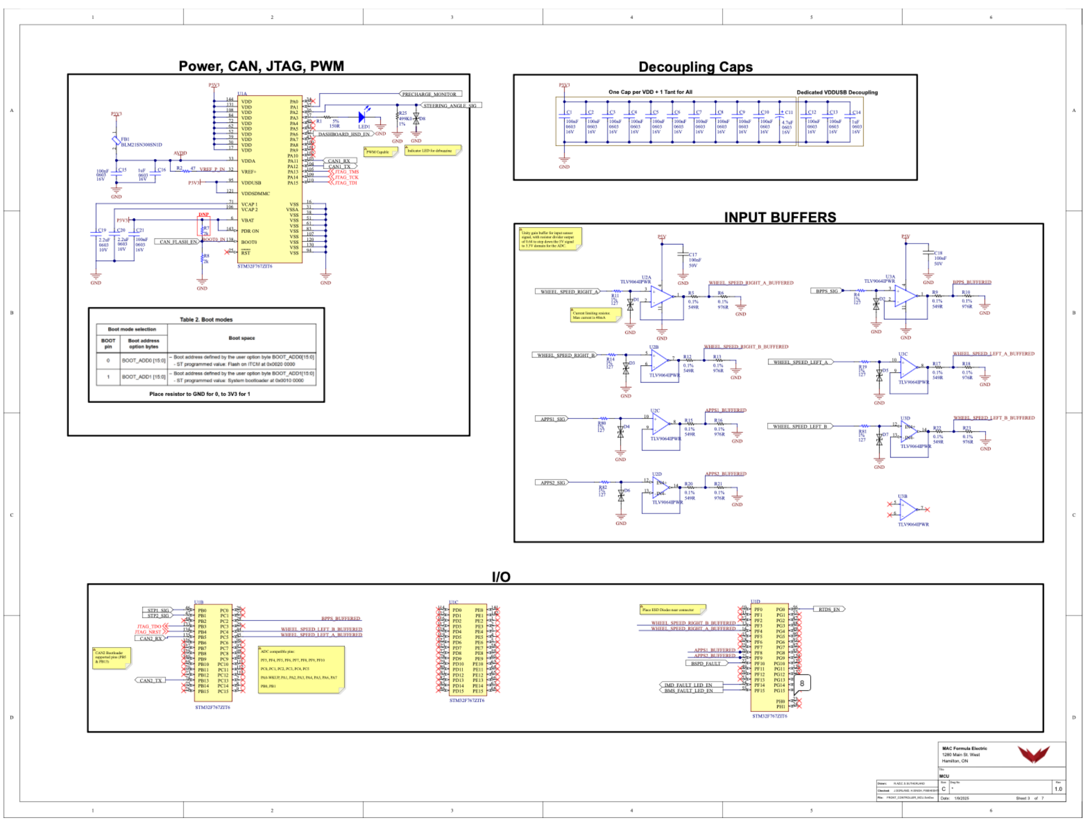


Figure 3: MCU Schematic

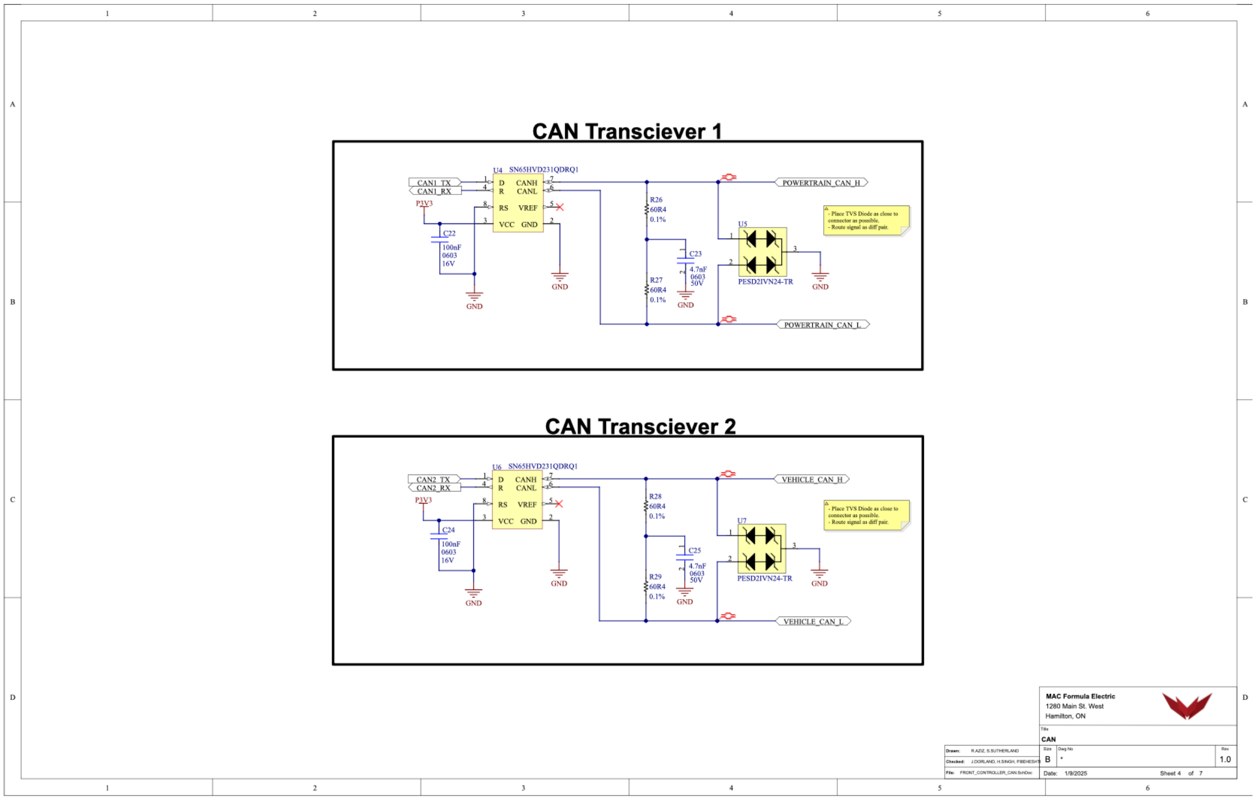


Figure 4: CAN Schematic

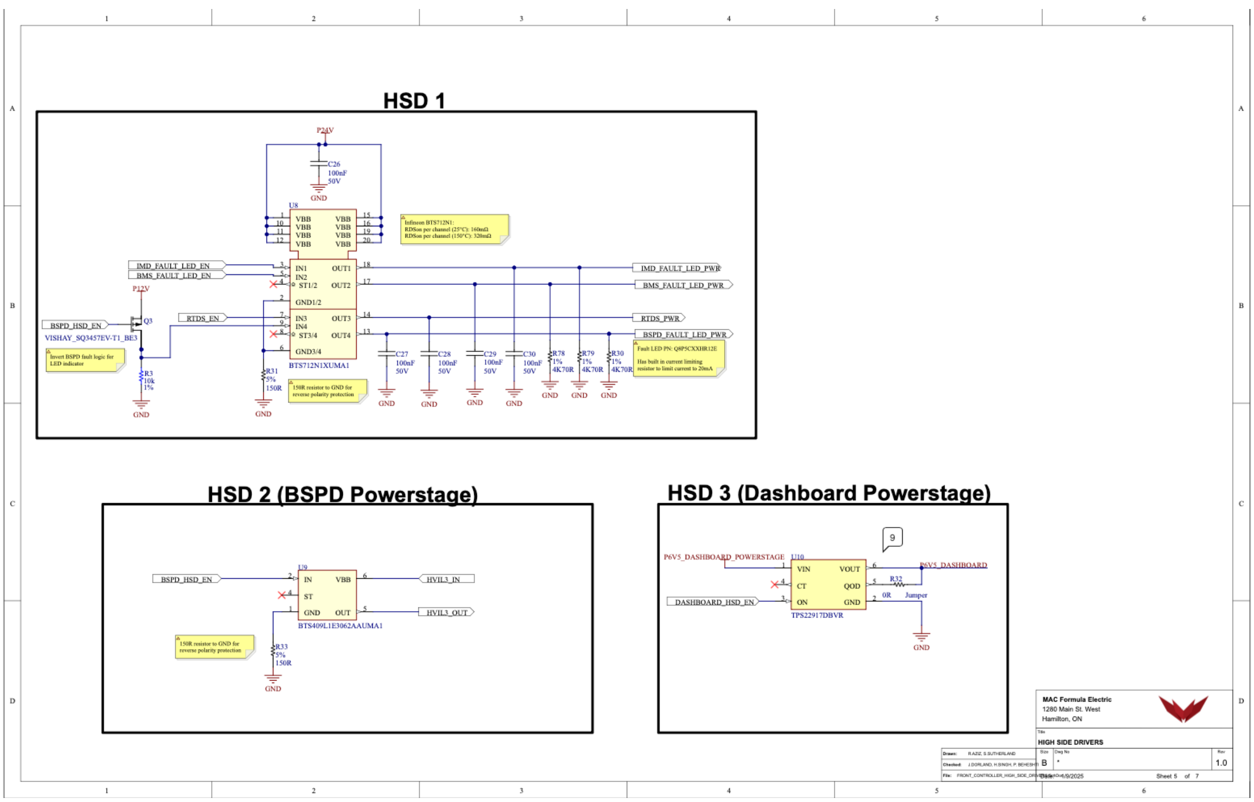


Figure 5: High Side Drivers Schematic

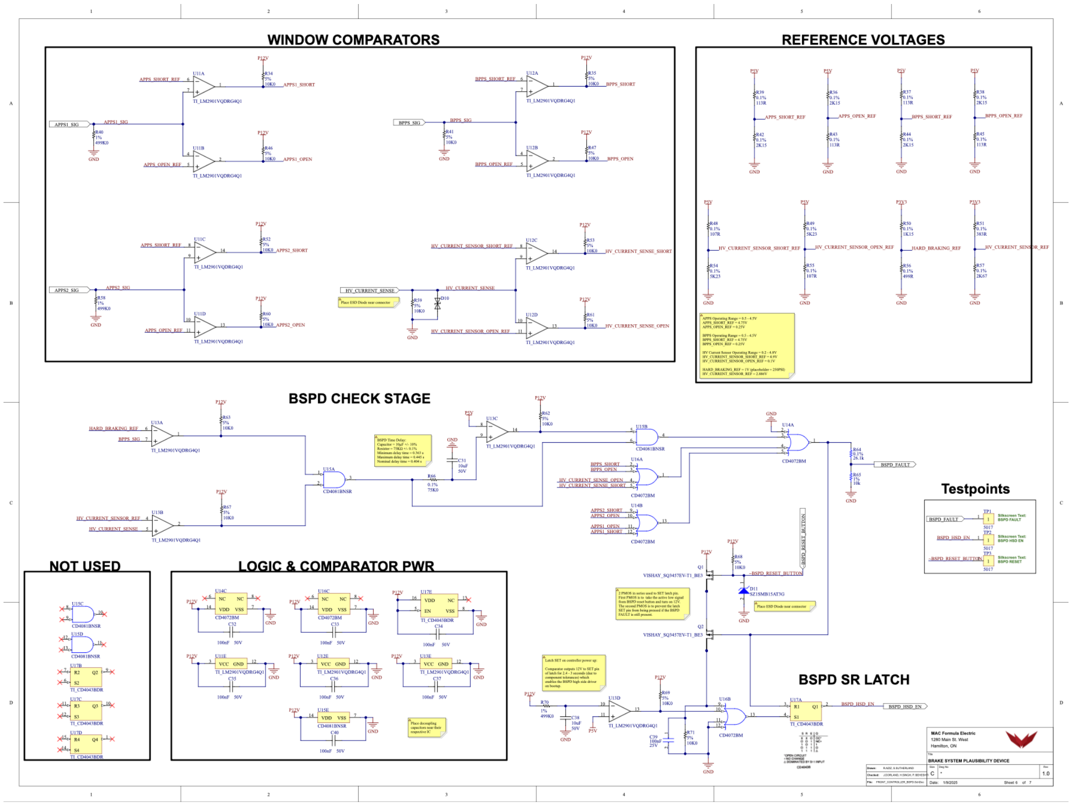


Figure 6: BSPD Schematic

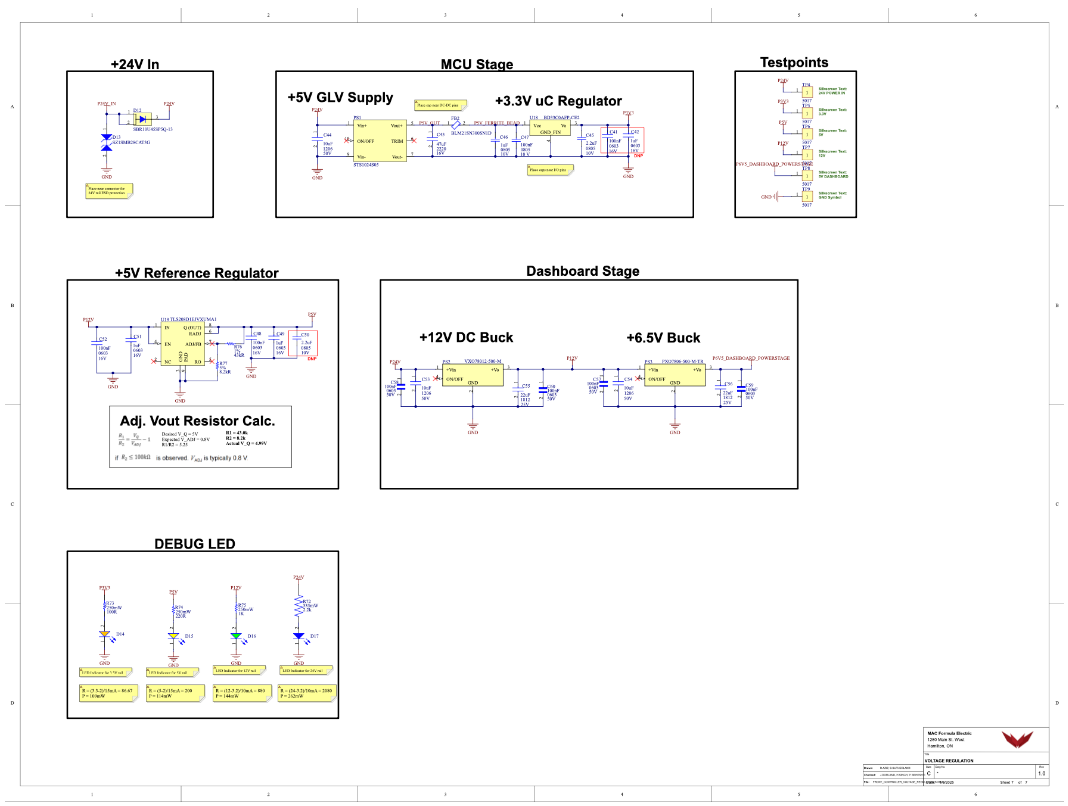


Figure 7: Voltage Regulation Schematic

3.2 PCB Layout

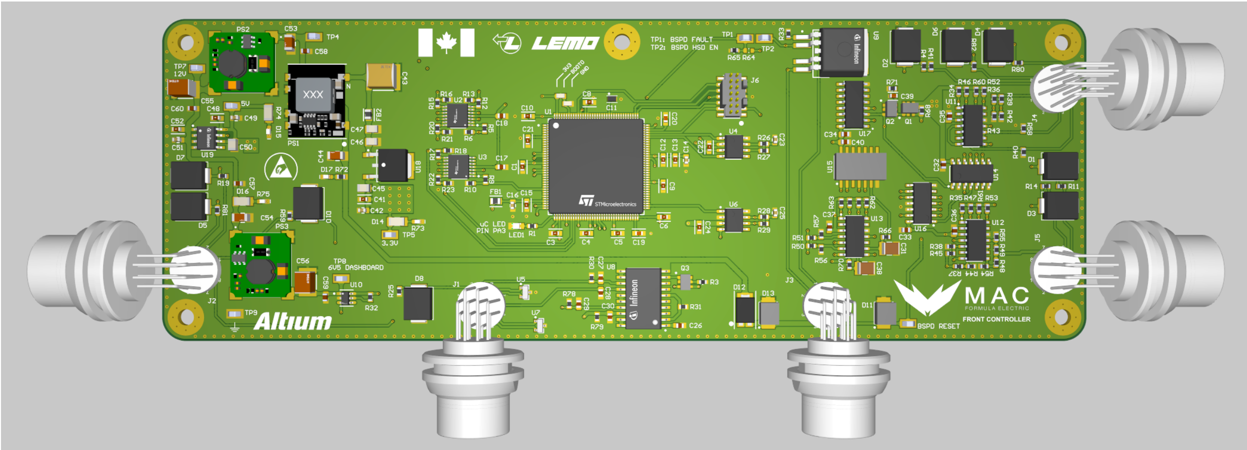


Figure 8: 3D Top View of FInished PCB

4 Design Criteria

<list out the general criteria or industry/design standards that the designer(s) will consider along the way in their decision-making.>

General design criteria:

- Reliability
- Power efficiency
- Lightweight
- Testable

5 Rules

<list out the applicable rules from the current season rulebook that will drive requirements for this design with section and number (e.g., *EV.7.5.1(a): The entire Tractive System and GLV System must be completely galvanically separated.*)

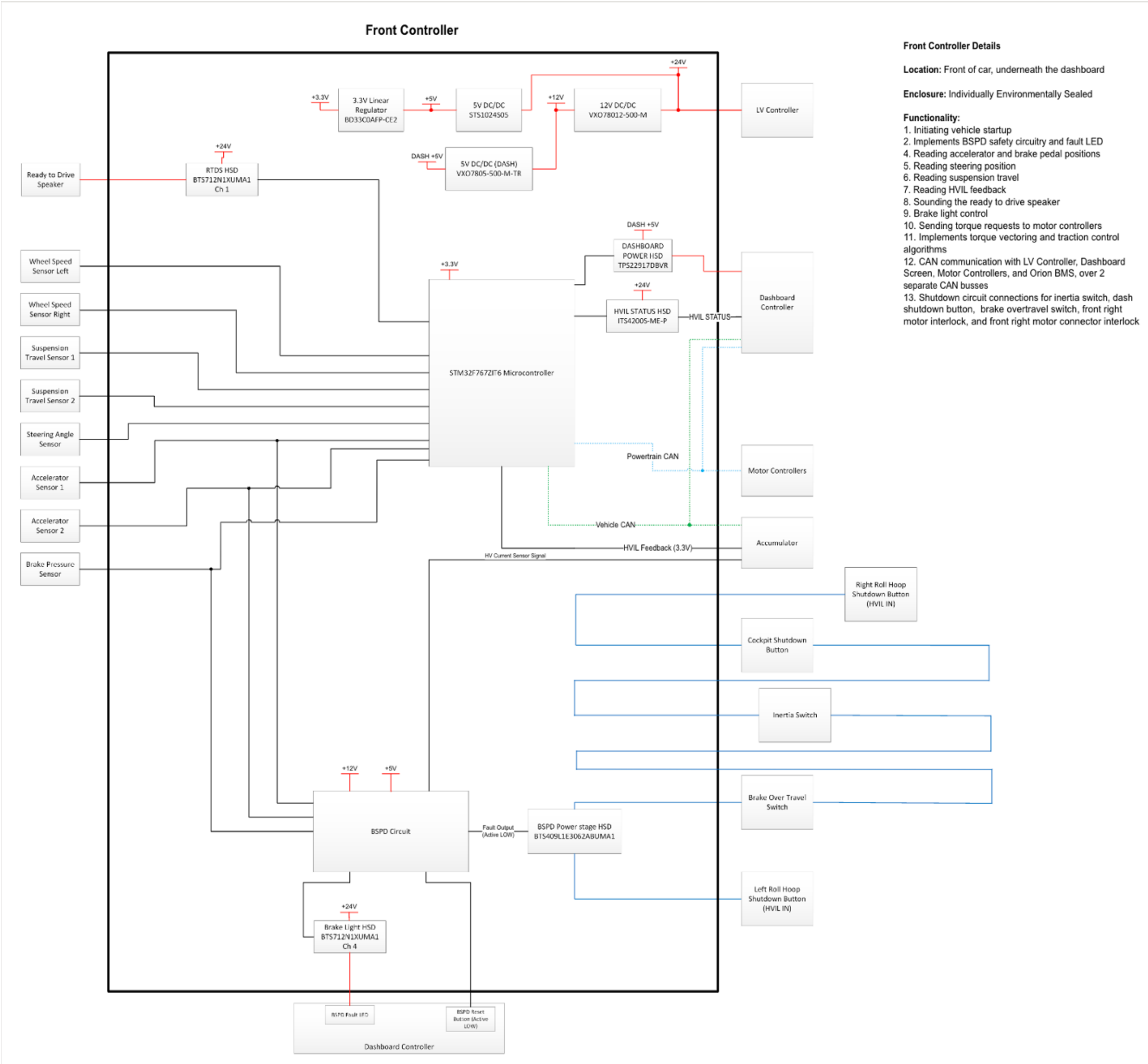
Or

Reference the attached print-out (in this document's appendix) from Polarion if this application is in use for capturing traceability between rules and requirements.>

Following the Formula SAE rules 2025

- EV.4.7 APPS / Brake Pedal Plausibility Check
- EV.5.9 Tractive System Active Light – TSAL
- EV.7 SHUTDOWN SYSTEM
  - EV.7.1.3
  - EV.7.1.4
- EV.7.2 Shutdown Circuit Operation
  - EV.7.2.3
- EV.7.7 Brake System Plausibility Device – BSPD
- EV.9 VEHICLE OPERATIONS
  - EV.9.3 Low Voltage (GLV) System
  - EV.9.4 Tractive System Active
  - EV.9.5 Ready to Drive

6 Design Overview



6.1 List of Changes from Revision 2

Change	Priority	Justification
CAN Flash EN	High	We want to be able to Flash all our STM32's via CAN instead of having to plug in the jtag for everyboard and flash them one at a time.
Removal of status button LED PWR	Low	This is a light we have on the dash of the car for the driver to see, we aren't going to need it anymore since we are just going to put this status on the display that we have on the car.
Make Unused HSDs "Miscellaneous"	Medium	Earlier, whenever we have HSDs that aren't in use we just leave them unconnected. Moving forward, we want to connect all of these and just make them "misc" connections.
BSPD Fault line feedback to MCU ADC	High	We want to connect this signal back to the stm32 (our MCU) so that software can know the state of the fault
LEDs on all power rails (different colors for different voltage) and LEDs on CAN lines	Medium	For debugging purposes we want to have an LED on the 3.3, 5, 12, 24V lines. This will make life a lot easier when testing the boards. Also we want LEDs on the CAN lines.
HVIL Unity Gain Buffere Removed	Low	No longer being used
Steering Sensor Change Pin to ADC Compatible	High	Steering angle is a critical input for vehicle dynamics algorithms like torque vectoring. It must be read by the MCU via an ADC-compatible pin.
Remove BRAKE_LIGHT_PWR and STATUS_BUTTON_LED_PWR change to IMD_FAULT_LED_PWR and BMS_FAULT_LED_PWR	Medium	Standardizing fault indication across the system and consolidating LEDs for more informative displays.
PS3 change to 6-9V regulator	High	Necessary for the new dashboard
Removal of HSD 4	Medium	No longer being used

6.2 Requirements

< list out requirements for this design based on design goals and rules listed in section 4.
Or
Reference the attached print-out (in this document's appendix) from Polarion if this application is in use for capturing traceability between rules and requirements.>

6.3 ECAD Circuit Design

<Provide detailed descriptions of each applicable element within the design overview, highlighting the engineering process that was utilized to arrive at your chosen design alternative and how it will meet the requirements outlined above. Include evidence such as mathematical computations/expressions or simulation data where possible.>

6.4 ECAD PCB Design

<Describe any considerations or design principles that are applicable to the hardware implementation of the circuit design based on design or rules requirements. Provide screenshots or data as evidence where applicable.>

6.5 MCAD Mechanical Design

<Provide detailed descriptions of each applicable element within the design overview, highlighting the engineering process that was utilized to arrive at your chosen design alternative and how it will meet the requirements outlined above. Include evidence such as mathematical computations/expressions or simulation data where possible.>

6.6 Packaging & Thermals

<Describe any considerations or design principles that are applicable to packaging and thermal management based on design or rules requirements. Provide screenshots or data as evidence where applicable.>

7 Testing and Validation

<Dedicate sub-sections within this section to break down the various acceptance test procedures to validate your design. Specify sequence of activities as applicable.>

7.1 Visual Inspection

Complete a visual inspection of the assembled board, checking for manufacturing and assembly defects. Document any issues below.

Pass? (YES/NO)	YES	Comments	

7.2 Impedance Matrix

Complete the following measurements according to the matrix arrangement in Ohms. Provide the approximation for measurements with long settlings times. Use **yellow** or **red** to denote measurements of concern

OL	GND	P24V	P12V	P6V5_DASHBOARD_POWERSTAGE	P5V	P3V3
GND		4.686k	3.2k	29.65k	463.4	1.046k
P24			5.27k	39.73k	5.14k	5.74k
P12V				4.49k	3.66K	4.24k
P6V5_DASHBOARD_POWERSTAGE					30.08k	30.7k
P5V						1.506k
P3V3						

7.3 Smoke Test

Upon completion of impedance matrix measurements, perform a basic smoke test of the board by applying +24V to J14 Pin 1 with GND connected to Pin 2. Document any issues below.

Pass? (YES/NO)	YES	Comments	

7.4 Supplies

Use a multimeter and an oscilloscope to measure the voltage and ripple of the power supplies using a 24V input. The circuits below may power through a different origin supply rail. Pay attention to the original source. Document any unexpected observations.

Net Name	Component	Voltage (V)	Ripple (V_{p-p})	Comments
P12V	ROF-78E12-0.5SMD-R	11.96	167.2mV	
P5V	TLS208D1EJVXUMA1	4.893	182.8mV	
P5V_OUT	STS1024S05	5.02	163.7mV	
P6V5_DASHBOARD_POWERSTAGE	PXO7806-500-M-TR	6.438	190.0mv	
P3V3	BD33C0AFPCE2	3.286	193.1mV	

7.5 HSD Test

Enable the following IO pins on the STM32 and test HSD outputs

IO Pin	Net Name	Output	Comments
PF14	BRAKE_LIGHT_EN		
PF15	STATUS_LED_EN		
PG0	RTDS_EN		
(BSPD Circuit)	BSPD_FAULT		
(BSPD Circuit)	BSPD_HSD_EN		
PA6	DASHBOARD_HSD_EN		
PA7	HVIL_LED_EN		

7.6 BSPD_FAULT_LED_PWR

Use a multimeter and an oscilloscope to measure the BSPD going to 12V using a 24V input.

Pass? (YES/NO)	YES	Comments	

7.7 BSPD_HSD_EN

Use a multimeter and an oscilloscope to measure the BSPD going to 12V for 24-30 ms using a 24V input.

Pass? (YES/NO)	YES	Comments	

8 Change Log

Date	Change